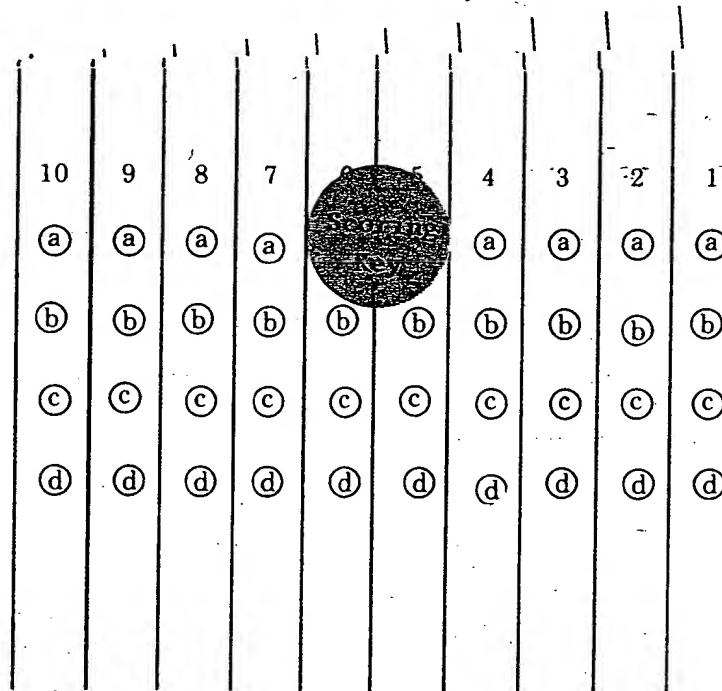


Doty

THE SMELL IDENTIFICATION TEST™ ADMINISTRATION MANUAL



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GENERAL INTRODUCTION

The purpose of this manual is twofold -- first, to provide information and normative data for valid administration and scoring of the Smell Identification TestTM (even by personnel not specifically trained in psychometric or sensory testing) and second, to review the initial studies of its development and application. Because this measuring instrument has only been recently developed, many of its potential uses have not been explored and even its most obvious applications have yet to be made. For this reason, this manual will be up-dated from time to time to include the results of more recent studies. Sensonics, Inc. would appreciate being informed of results and publications based upon the application of this test so that this information can be made available in subsequent editions of the manual.

Until the development of the Smell Identification TestTM, no convenient means for quantitatively assessing smell function in a standardized manner was generally available. By incorporating microencapsulation technology and sound psychometric principles, the Smell Identification TestTM clearly filled this void. Despite the fact that the test was initially envisioned to provide only a first-step olfactory "screening" function, it became quite clear in both the clinic and laboratory that the test was much more broadly useful than initially anticipated. Indeed, it was found to be sensitive to a number of subject variables and to correlate more closely, in the clinical setting, with patients' complaints and other indices of dysfunction than measures from more traditional threshold and suprathreshold psychophysical tests. Furthermore, its high reliability has allowed it to be used in situations where previous odor identification tests were found wanting.

There is no doubt that this test has limitations in some subject groups and in some test situations, and future work will better define the limits of its applicability. For example, the test cannot be validly administered to persons with limited language ability. However, as indicated by the normative data contained in a subsequent section of the manual, it is applicable to nearly all English-speaking individuals beginning at a very young age. The test is currently being translated into several other languages and the interested investigator should contact Sensonics, Inc. for details of the release of these versions of the test. In addition, a non-verbal version of the test will soon be available for use in testing very young persons or individuals with limited language ability.

Overall, the available research data suggest the Smell Identification Test™ is highly sensitive, broadly applicable, and very useful in situations where dysfunction of the olfactory sense is present or suspected. In addition, such data indicate that it is helpful in discriminating between persons with mediocre smell function and those with a more highly developed sense of smell, as is needed in the screening of sensory panels for various industrial applications.

This manual is organized into two major sections. The first section is a review of the research work that went into the development of the test, whereas the second is a presentation of the procedures that should be followed for its valid administration.

It is absolutely essential that the test administrator be familiar with Section II, as it provides details of how the test should be administered and scored.

Although it is not absolutely necessary to read Section I of the manual to validly use the test, it is recommended that this material be read by the test administrator. A knowledge of this information will provide a better understanding of the strengths and weaknesses of the instrument which, hopefully, will translate into its most appropriate application and interpretation.

SECTION I

Development of the Smell Identification TestTM

Although the initial studies describing the development of the Smell Identification TestTM are presented elsewhere [1-3], a brief overview of their procedures and findings is presented in this section. For the sake of brevity and clarity, many of the methodological and statistical details are omitted, and the interested reader is referred to the earlier publications for more specific information.

Five initial experiments, outlined in order below, led to the development of the Smell Identification TestTM, although the test had as its basis an earlier prototype mentioned elsewhere [4]. In the first two experiments of this series [see 3], selection of the most appropriate stimuli was made. Subsequently, the influences of variables such as the age, gender, and ethnic background of the subjects on the scores of the developed test were examined. In the third experiment, the utility of the test in discriminating among persons with known or suspected olfactory disorders, as well as persons instructed to feign total anosmia, was established. In the fourth experiment, the instrument's test-retest reliability was determined, whereas in the fifth its scores were compared to measures derived from a traditional detection threshold procedure.

Experiment 1

Experiment 1 had four main goals. The first was to quantitatively establish, in subjects with no apparent olfactory dysfunction, psychological ratings of the perceived intensity, pleasantness, familiarity, coolness-warmth, and irritation of 50 Microfragrance samplesTM of potential use in a standardized olfactory test. Such data provided basic information as to the suitability of microencapsulated odorants for testing human olfaction, as well as a basis for eliminating stimuli with problems of identifiability, irritability, or intensity from the final version of the test. The second goal was to determine whether such ratings were influenced by two means of releasing the odors from the microencapsulated crystals (scratching the surface with #120 sandpaper or with a pencil tip) and, if so, whether one means was clearly preferable to the other. The third goal was to ascertain if males and females differentially rated the stimuli (as was expected if odorants released from microencapsulated crystals behaved similarly to those from other stimulus sources; see 5-7), whereas the fourth goal was to

ascertain the relative identifiability of the 50 Microfragrance samplesTM when no verbal or written cues were provided as to their identity. This information, in conjunction with that collected in the next study (Experiment 2), was utilized to eliminate stimuli that were difficult to identify.

Fifty men and women (half of each sex; mean age = 24.87 yrs, SD = 5.52 yrs) with self-reported normal smell function rated the intensity, pleasantness, coolness/warmth, irritation, and familiarity of 50 microencapsulated odorants on standard 9-point category rating scales [see 8]. The stimuli were chosen on the basis of a number of criteria, including (a) being composed of single, as well as of multiple, components (given the possibility that the olfactory system codes information using a multiple profile/multiple receptor site process; 9), (b) spanning a number of qualitative odor classes [10], (c) evidencing (in most cases) no intranasal trigeminal stimulative properties, and (d) evidencing, in selected cases, clear-cut trigeminal stimulative ability to allow for possible detection of malingering [8].

In general, the results indicated that (a) none of the 50 odorants were perceived too extreme on any of the continua to warrant immediate exclusion from further consideration as test stimuli (Figure 1), (b) the odors differed among one another on each of the perceived attributes (Figure 1), (c) women rated the odors, on the average, as slightly more intense, more unpleasant, less cool, less irritating, and more familiar than did men, and (d) that both the sandpaper and pencil release procedures produced reasonably similar results (Figure 1). However, a few slight differences were observed between these two modes of releasing the stimuli. For example, the stimuli were rated, on the average, as slightly more familiar and less pleasant when released by sandpaper than when released by pencil. In addition, women rated stimuli released by pencil as slightly stronger (although of equal familiarity) than those released by sandpaper. Despite the fact that there was a significant tendency for the familiarity ratings to differ between the sexes as a function of the odorants evaluated, the stimuli rated as more familiar by men than by women did not differ in any obvious way from the other odorants.

Based on the findings that odors released by pencil were judged slightly less familiar than those released by sandpaper, and that women rated odors released by sandpaper stronger than odors released in this manner by men [in accord with the sex difference noted in other human olfactory work (e.g., 5-7)], sandpaper was chosen as the means for releasing the stimuli in subsequent studies.

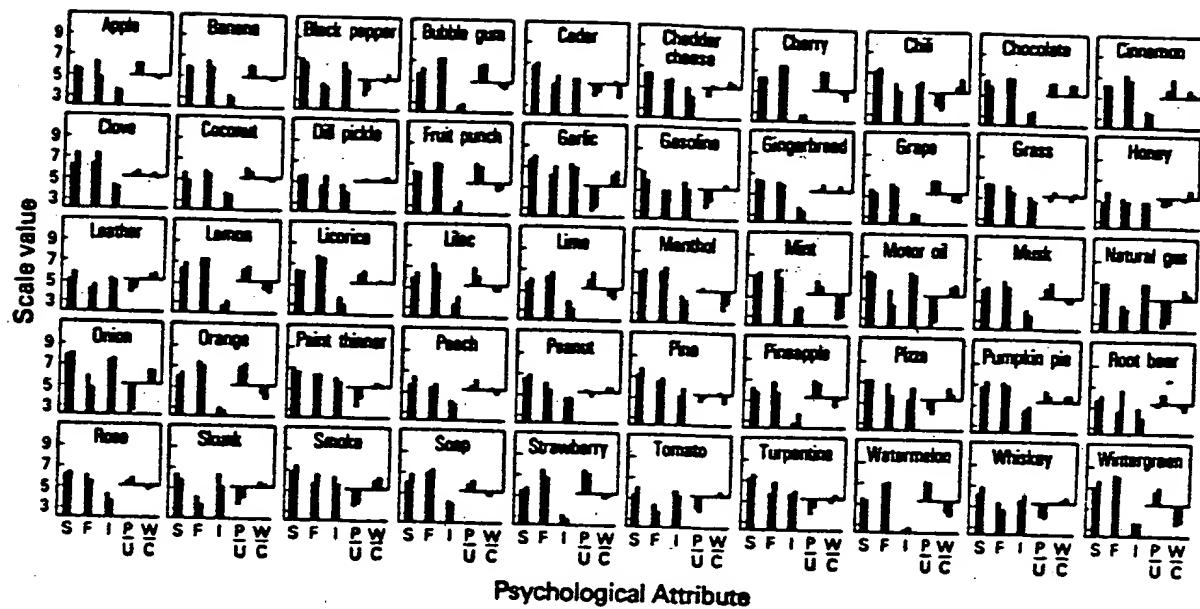


Fig. 1: Mean category ratings given to 50 microencapsulated odorant strips using #120 sandpaper (left half of each vertical bar) or the tip of a #2 lead pencil (right half of each vertical bar). S = Strength (intensity); F = Familiarity; I = Irritation; P/U = Pleasantness/Unpleasantness; W/C = Warm/Cool. For the P/U and W/C scales, the horizontal line signifies the neutral reference point. Note, for example, the marked unpleasantness and irritation ratings given to onion, but not to rose, and the coolness attributed to menthol. From [3] with permission.

Experiment 2

Experiment 2 had three main goals: First, to determine the relative identifiability of the stimulants in a forced-choice situation where alternative responses were provided; second, to omit stimuli from inclusion in the test which were not correctly identified by the majority of a large number of normal subjects; and third, to evaluate the relative influences of several subject variables, alone and in combination, upon the test scores of a large and heterogeneous group of subjects.

In the initial phase of the study (where the identifiability of the odors was established), 1198 subjects were tested. These volunteers consisted of (a) participants of regional health fairs and public events, (b) primary and secondary public school students, (c) university students, (d) residents of homes for the elderly, and (e) employees of the Hospital of the University of Pennsylvania. Persons reporting any smell abnormalities or who were unable to correctly identify at least half of the stimulants were not included in this study group. Seventy-three percent

were White Americans and 21% Black Americans, with most of the remaining 6% not indicating their ethnicity. Sixty-two percent were female and 38% male. Eighty percent were current non-smokers, and 19% current smokers, with the remainder not reporting this information. Although a wide spectrum of ages was present in this group, disproportionately more subjects fell within the younger age ranges, as indicated by the following statistics: mean age = 35.24 (SD = 19.21); modal age = 19.0; median age = 29.29; 25th percentile = 18.88; 75 percentile = 50.3. Overall, the average ages of the two sexes, of the two major ethnic groups, and of the smokers and non-smokers were similar [see 31].

In the second phase of this study (where the influences of age, gender, race, and smoking habits upon the test scores were evaluated by multiple regression analysis), the data from most of the subjects mentioned above and from an additional number of persons (mostly elderly) were subjected to analysis. Although test scores of 1365 subjects were initially evaluated, data from 26 with apparent anosmia were omitted from the data set upon which the final regression equation was computed.

A preliminary 50-item 5-booklet Smell Identification TestTM was developed for administration in Experiment 2. In this test, which was identical in general format to the 40-item version, the 50 stimulants were presented in random order, with the exception that odors of similar psychological quality (e.g., garlic and onion) did not directly follow one another.

To aid in the selection of sets of distinct descriptors for the multiple alternative choices of each of the 50 items, the names of 51 descriptors were typed on small cards. Fifty of these names were those assigned by the manufacturer to the Microfragrance samples^{TM*}, whereas one was that of "cola". These cards were then arranged by two female technicians and the author spatially on a table top with the goal of making the distances between the cards proportional to the psychological similarity of the odor items. For example, the garlic and onion written labels were located close to one another, whereas the chocolate and gasoline labels were placed apart from one another and at differing distances from those of onion and garlic. This simple procedure resulted in a two-dimensional space from which the three "distractor" items were selected for each odorant so as to insure their distinctiveness from one another as well as from the odorant of interest.

*Microfragrance samplesTM is a registered trademark of the 3M Corporation, St. Paul, Minnesota.

In addition to sampling response alternatives relatively distinct from one another, an attempt was made to use each of the verbal descriptors equally often and about the same number of times in the four response category positions (a,b,c & d). Although it was not possible to achieve all of these aims simultaneously, this goal was approached. Thus, 37 of the 51 descriptors appeared four times apiece, eight three times apiece, five five times apiece, one six times, and another once. No descriptor ever appeared more than twice in any of the response category positions.

As indicated in Figure 2, it was apparent that a number of the Microfragrance samplesTM were poorly identified by the majority of the subjects, even though the responses were cued by written alternatives. Based on these findings and other identifiability

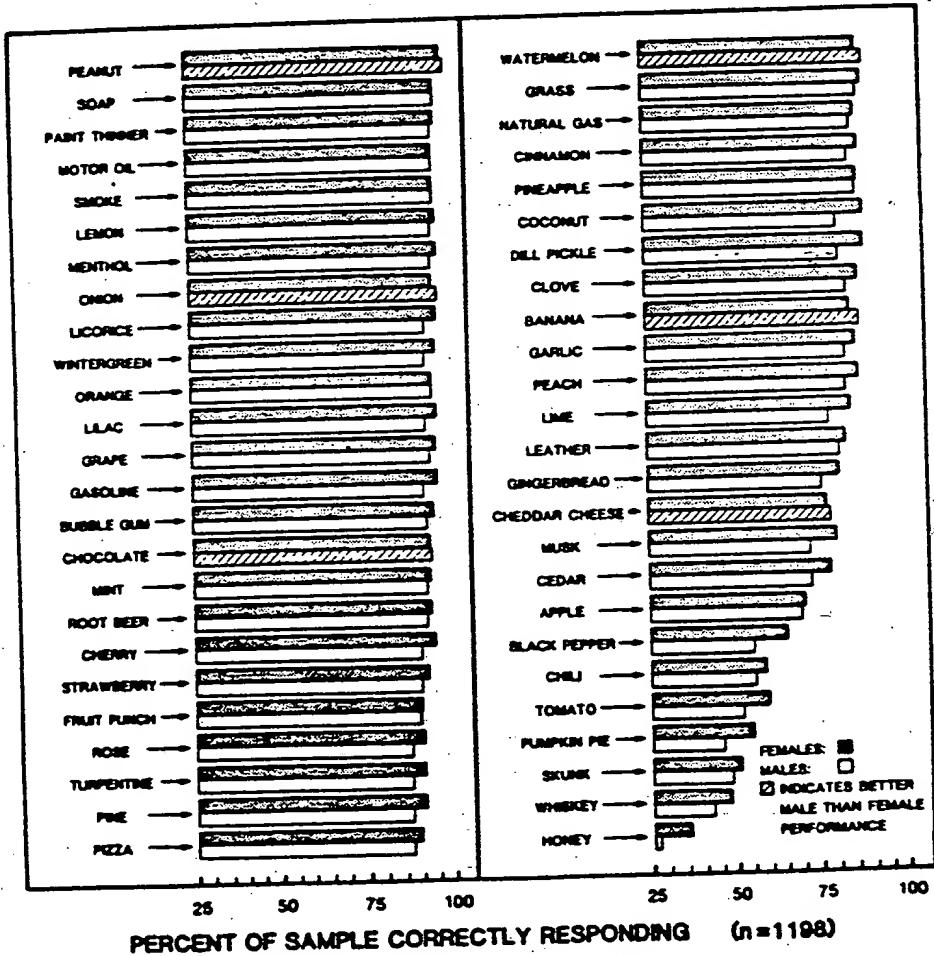


Fig. 2: Percent of subjects correctly identifying each of the 50 target microencapsulated odorants presented in a 4-alternative forced-choice response paradigm. Note that women performed better than men on most of the stimuli. From [3] with permission.

data published elsewhere [3], the following stimuli were eliminated from inclusion in the 40-item final version of the Smell Identification TestTM: apple, black pepper, chili, honey, musk, pumpkin pie, skunk, tomato, and whiskey. In addition, garlic was eliminated from the final test due to its psychological similarity to onion.

To determine what influence a number of demographic variables had on the test scores (for the 40 items included in the final test), a series of multiple regression analyses were performed on data from 1339 to 1365 subjects (missing data for some variables necessitated using fewer subjects in some instances). The final regression equation fitted to subjects with Smell Identification TestTM scores 20 or greater included only variables significant at the .05 level (n = 1339):

$$Y = 33.399 + 1.055X_1 + 0.217X_2 - 0.003X_2^2 - 0.489X_3 - 1.008X_4 - 1.040X_5 - 2.172X_6 + e,$$

where $X_1 = 1 (0)$ if the subject is female (male); $X_2 =$ age of subject in years; $X_3 = 1 (0)$ if the subject does (does not) currently smoke; $X_4 = 1 (0)$ if the subject is (is not) nonwhite; $X_5 = 1 (0)$ if the subject does (does not) report a smell problem; $X_6 = 1 (0)$ if the subject does (does not) belong to an elderly sub-file (i.e., persons primarily in old-age homes who are over 65 yrs of age), and $e =$ error term.

The R^2 value of this equation was 0.411 (SD = 3.318), and the standard errors of estimate for the seven variables were as follows: $X_1 = .188$; $X_2 = .023$; $X_2^2 = .0003$; $X_3 = .238$; $X_4 = .222$; $X_5 = .302$; and $X_6 = .525$.

Overall, these analyses indicated that gender, age, ethnic background, and smoking habits all relate significantly to scores on the Smell Identification TestTM. Obviously, gender and age account for most of the variance. The relation between age, gender and Smell Identification TestTM scores is depicted in Figure 3. Note that men evidenced lower average test scores than women within nearly all age groups, and that both sexes evidenced a decrease in test performance beginning in the sixth decade of life which continued through the ninth decade.

To establish if the decrease in the scores across the older ages was due, in whole or in part, to a general decrement in memory function, the Wechsler Memory Scale (WMS, Form II) [11] was administered to 47 persons above 55 yrs of age within a day of the olfactory tests (mean age = 81.32, SD = 7.75). Because 16 of

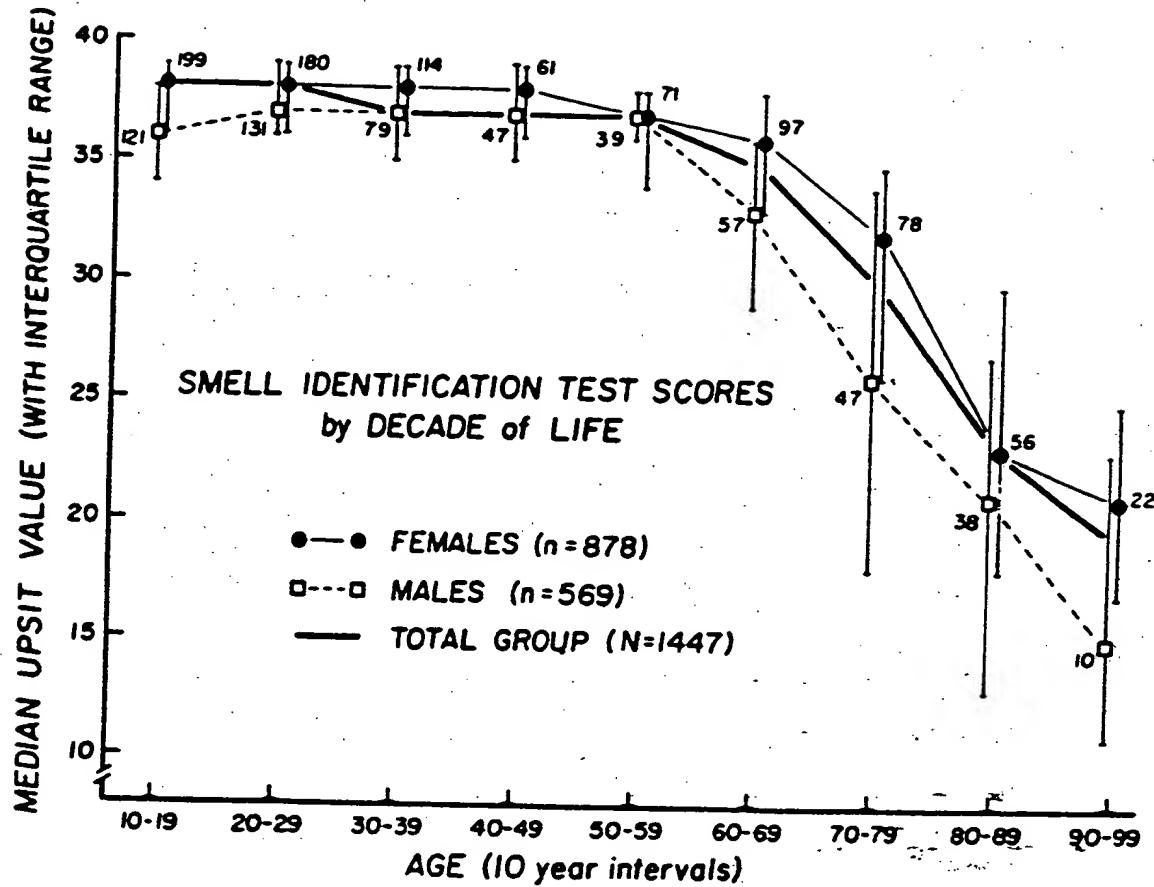


Fig. 3: Relationship between Smell Identification TestTM scores, age, and gender in a large heterogeneous group of subjects. From [3] with permission.

these individuals evidenced total anosmia, only data from those scoring 20 or above were subjected to analysis. As indicated in detail elsewhere [3], partial correlations revealed that no appreciable relationship was present between the Smell Identification TestTM scores and the WMS scores ($r = .027$, ns), despite the fact that both of these tests significantly correlated with age, per se [r (smell score, age) = $-.51$, $p <$ average Smell Identification TestTM scores with age reflects a perceptual deficit largely independent of the memory deficit measured by the Wechsler Memory Scale.

Experiment 3

The goal of Experiment 3 was to validate the Smell Identification TestTM by establishing its ability to distinguish among (a) persons with normal olfactory function, (b) persons with known or suspected olfactory dysfunction, and (c) persons instructed to feign total anosmia under the make-believe condition of receiving a large insurance payment if they successfully did so.

Five groups of subjects were administered the test:

(a) 1215 persons with normal smell function (mean age = 33.69 yrs, SD = 17.69; essentially the study population evaluated in Experiment 2 minus persons over the age of 65);

(b) 51 persons with total bilateral anosmia (mean age = 40.76 yrs, SD = 20.75); 15 had Kallmann's syndrome, with the remainder being anosmic from a number of causes [see 3]);

(c) 21 men with Korsakoff's syndrome (mean age = 57.05, SD = 8.13), an organic brain syndrome associated with a consistent pattern of lesions in the midline areas of the brainstem and diencephalon and impairment on numerous tests of olfactory function [15-17];

(d) 31 persons with multiple sclerosis (mean age = 49.03, SD = 12.56); and

(e) 158 persons with normal smell ability who were instructed to feign total anosmia under the make-believe condition that they would collect a large sum of money from an insurance company if they successfully did so. One hundred and three of these individuals had a least one year of college, whereas the remainder had a high school education or less.

As indicated in Figure 4, persons with total bilateral anosmia evidenced scores on the Smell Identification TestTM only slightly above the number expected on the basis of random responding (Mean number correct = 12.25, SD = 3.04; Median = 13). This slightly higher than chance performance was due to the inclusion of several trigeminal stimulants in the test.

Most of the Korsakoff patients evidenced aberrant scores, with a wide range in the degree of deficit being present (Mean = 15.95, SD = 7.97; Median = 14; Range = 5 - 37; Figure 4). The recent demonstration of a high correlation between scores on the Smell Identification TestTM and lumbar CSF levels of 4-methoxy-3-hydroxy-phenyl glycol (a major metabolite of norepinephrine) in a subgroup of these patients suggests that the divergent scores may reflect the degree of CNS noradrenergic pathway damage [12]. Assuming this to be the case, the Smell Identification TestTM may serve, at least in these types of patients, as a nonobtrusive index of the degree of such CNS damage.

Patients with multiple sclerosis typically scored within the normal range, although a disproportionate number fell into the

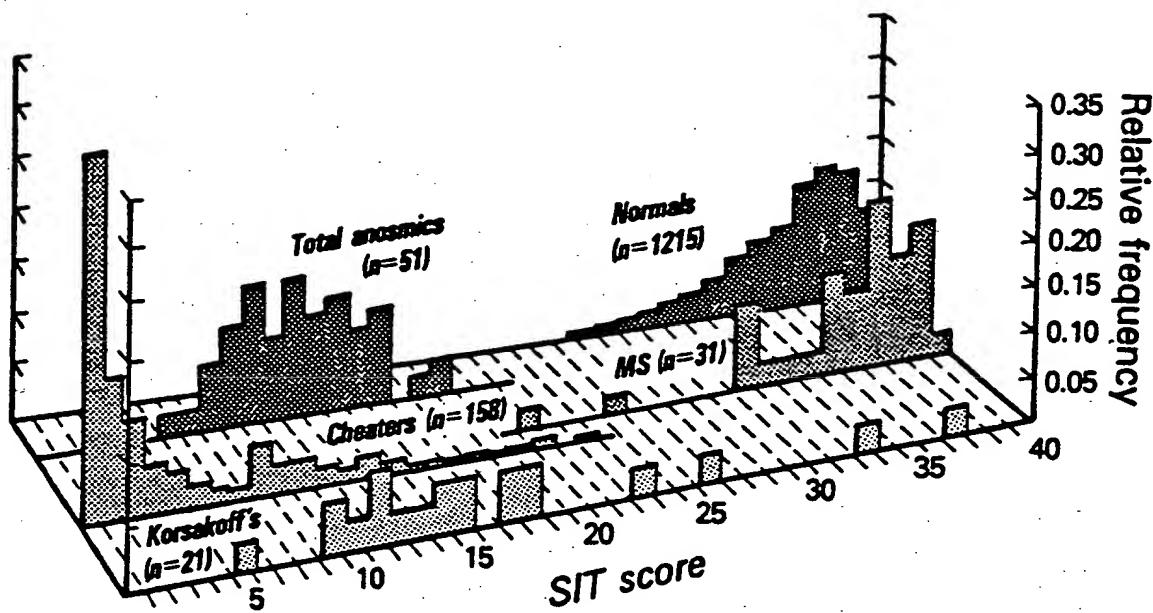


Fig. 4: Smell Identification TestTM scores for five groups of subjects. SIT = Smell Identification Test. See text for details. From [3] with permission.

lower section of this range, and two fell outside this range (Figure 4). A partial correlation (factoring out the effects of age, *per se*) revealed a weak but statistically significant relationship between the Smell Identification TestTM scores and the estimated duration of the disease ($r = -.428$, $p < .05$).

It is apparent in Figure 4 that subjects asked to feign total anosmia reported fewer correct responses than expected on the basis of random responding or than observed in persons with well-documented total anosmia. Indeed, the modal number correct in this group was zero. Overlap between the distribution of these "cheaters" with that of the total anosmics was minimal. No differences were observed between the responses of the college-educated and non-college educated subjects.

Experiment 4

A major factor which determines the usefulness and validity of a test is its reliability or stability over time; i.e., its ability to consistently measure what it is intended to measure. The purpose of Experiment 4 was to determine the test-retest reliability of the Smell Identification TestTM.

Twenty-three women and 30 men (mean age = 44.13 yrs, SD = 19.98) were selected from our subject population for readministration of the Smell Identification TestTM at an interval exceeding six months from the time of the initial test. To allow for a valid computation of the test-retest reliability coefficient, we selected persons who represented the entire continuum of possible scores on the initial test. The final study group consisted of five persons with initial test scores in the 6 to 11 range, seven with scores in the 11 to 15 range, four with scores in the 16 to 20 range, thirteen with scores in the 21 to 25 range, five with scores in the 25 to 30 range, eight with scores in the 31 to 35 range, and eleven with scores in the 36 to 40 range.

As indicated in Figure 5, the scores were extremely stable despite the long interval between the two test administrations. The Pearson ρ between the two sets of test scores was .918 ($p <$ regression line fitted to these data (1.409) suggests the possibility that at least some of the subjects improved their performance slightly on the second test administration. Whether this slight change reflects a change in olfactory function or simply is due to sampling artifacts requires further study.

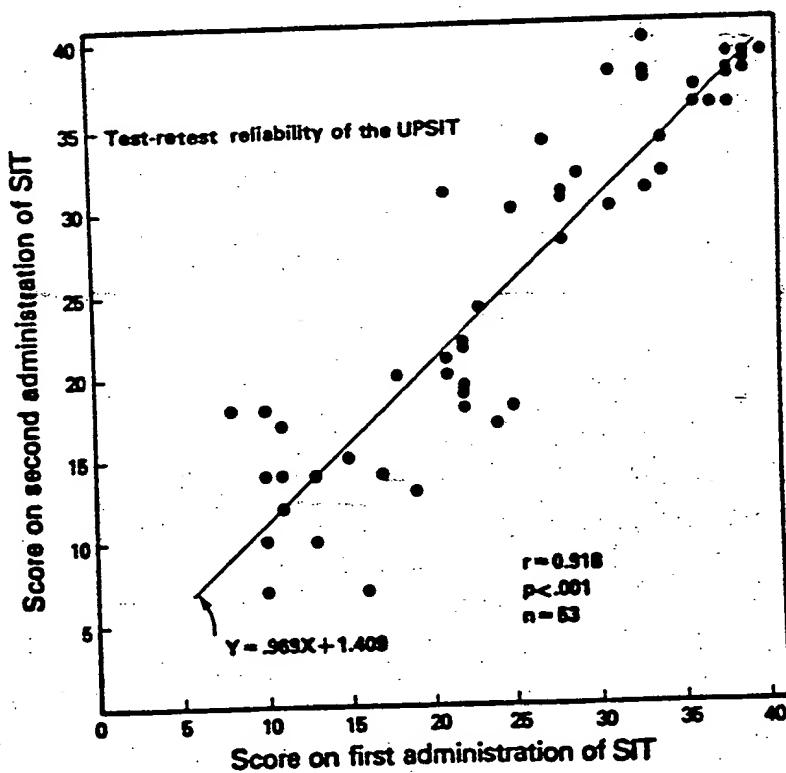


Fig. 5: Test-retest relation between Smell Identification TestTM scores in a group of subjects tested on two occasions separated by a minimum of six months. From [3] with permission.

Experiment 5

The goal of Experiment 5 was to ascertain whether scores on the Smell Identification TestTM correlate significantly with measures from a traditional odor detection threshold task. Although, theoretically, scores on a suprathreshold identification task need not correlate with detection threshold values, some degree of relationship would be expected if both tests were sampling a common domain of olfactory function.

Sixty-four men and women (mean age = 42.41; SD = 18.93) were evaluated. With the exception of six college students, these individuals were patients at the Smell and Taste Center of the Hospital of the University of Pennsylvania and evidenced varying degrees of olfactory function. Thus, a comparatively broad range of scores on both the Smell Identification TestTM and the threshold test was represented.

The subjects were administered the two tests on the same day. The threshold test was a slight modification of the forced-choice single-staircase procedure described by Ghorbanian et al [21]. A trial consisted of the presentation of two 100 ml glass sniff bottles in rapid succession in a standardized manner [see 8]. One bottle contained a given concentration of perfume-grade phenyl ethyl alcohol (a rose-like odorant relatively free of trigeminal stimulative ability) dissolved in 20 ml of propylene glycol, whereas the other contained 20 ml of propylene glycol alone. The subject indicated which of the two randomly-presented bottles evoked the stronger sensation. Even if no difference was noted, the subject was required to choose one or the other bottle. No feedback was provided as to the correctness of the responses.

The staircase was begun around the -6.0 log concentration step of a half-log step (volume/volume) dilution series extending from -6.50 to -1.00 log steps (two trials per step) and moved upwards in single log steps until correct detection occurred on two successive trials. At this point, two additional trials at that concentration level were given to decrease the likelihood of chance performance at that concentration. If a correct response did not occur on both of these trials, the staircase was moved upwards in 1.00 log steps until detection occurred on four consecutive trials at a given concentration. When correct responses occurred on all four trials, the staircase was reversed and subsequently moved up or down in 0.50 log increments or decrements, depending upon the subject's performance. Thus, the staircase was moved up 0.50 log units if an incorrect response occurred on either of the two trials, and down 0.50 log

increments if a correct response occurred on both trials. If an incorrect response occurred on the first of the two trials, the second trial was not run and a new pair of trials was begun at the appropriate next higher concentration. A minimum of 20 seconds was interposed between the pairs of trials. The geometric mean of the first four staircase reversal points following the third staircase reversal was used as the threshold measure. In cases where a subject's threshold was located outside the -6.50 to -1.00 log concentration range, the procedure of assigning the subject either the -6.50 or the -1.00 log step value, as appropriate, was adopted.

The relation between the Smell Identification TestTM scores and the detection threshold values is presented in Figure 6. Although the correlation between the two sets of measures was remarkably strong ($r = -0.89$, $p < .001$), it was likely inflated by the large number of scores of total anosmics which clustered at the lower end of the continua. When these scores (see box in Figure 6) were omitted from the computation, the correlation coefficient was -0.794 [$p < .001$].

A discussion of the findings of Section I in relation to other literature studies is presented in another publication [3].

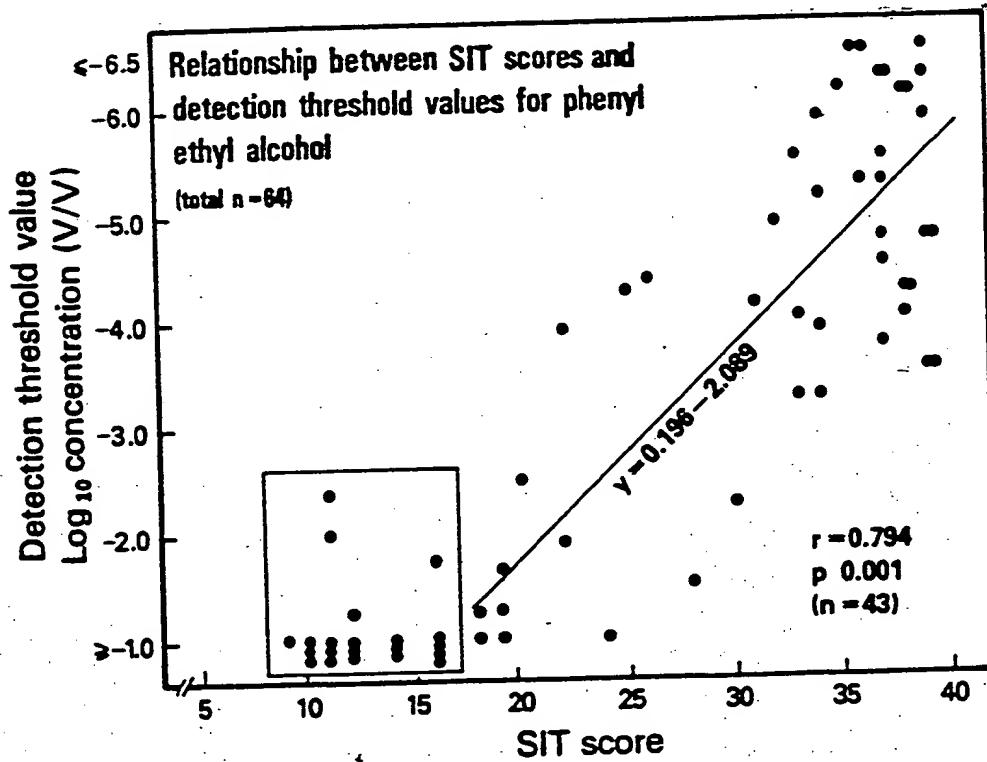


Fig. 6: Relationship between detection thresholds for phenyl ethyl alcohol and Smell Identification TestTM scores. From [3] with permission.

SECTION II

Administration and Scoring of Smell Identification TestTM

Section II should be carefully read before administering the Smell Identification TestTM. As with any psychometric instrument, the Smell Identification TestTM should be administered only by qualified professional personnel. Furthermore, the norms for this test and this manual should never, under any circumstances, be given to anyone not professional engaged in the scientific or medical evaluation of smell function. We recommend that this test manual and the copies of the Smell Identification TestTM be stored in a locked secure place when not in use and that, under no circumstances, the examinee be allowed to keep the test or be given direct access to its means of scoring. To insure the validity of the test, tests stored over 6 months should be evaluated by scratching the microencapsulated odor labels on a small corner section to be certain that the odors have not changed in quality.

Administration Procedures

The Smell Identification TestTM was designed to be self-administered by most literate individuals. However, care must be taken to insure that the instructions are followed exactly, and persons to whom the test is sent through the mail should be re-instructed (in a cover letter) as to the importance of providing a response to all items even if no odor is detected. In addition to failing to correctly follow instructions, some persons (particularly those with smell disorders) use the sandpaper too strongly when releasing the odorants and, essentially, sand the entire microencapsulated test strip down to the base paper. For this reason, it is best to inform the subject of this problem and to tell them to scratch the odorized surfaces by making only a few firm scrapes. For subjects being tested under supervision, it is best that the examiner or supervisor release the first odor for the subject by scratching the surface appropriately. The examiner should then indicate to the subject that this is the exact manner in which all subsequent odors should be released and that sanding is not permitted. It is essential that the subject read over the instructions before beginning the test, and that the items are sampled in chronological order. Immediately after completion of the test, the test administrator should examine it to insure that all items are complete. If not, the test should be returned to the subject immediately for completion of the

uncompleted items. Because the normative data are based upon all 40 items, incomplete booklets cannot be validly scored.

The examiner must help administer the test to persons who have impaired eyesight or who, on the basis of age or other factors, cannot read the alternatives or adequately release the odorants. In such cases, the examiner should obtain the information on the back of Booklet #1 verbally and fill it in for the subject and place the subject's name on the spaces provided on the other three booklets. The examiner should then use the sandpaper to correctly release the first odor, hold it under the subject's nose, and read aloud the response alternatives while the subject is sniffing the microencapsulated strip. In cases where the subject's eyesight is not impaired, it is permissible to allow the subject to read the alternatives as they are mentioned verbally. Finally, the examiner should mark the subject's response to each item on the columns provided on the booklet's response page. When extremely old people are tested with this instrument, it is permissible to spread the testing out over several sessions to minimize any problems associated with their attention spans or willingness to cooperate.

Because of the medical, psychological, and ethical considerations involved in assessing sensory function, it is imperative that the results of the Smell Identification TestTM be interpreted within the entire context of the individual's occupation, general health, and psychological state. For example, a score of 20 on the test is quite a different matter for a 40-year old chef than for a 40-year old sanitation worker. Likewise, as will be seen in the next section, the individual's age and gender must be taken into consideration when evaluating the test results. While a score of 20 is very abnormal for a 30 year old male (falling completely out of the range of a normal control group), such a score is not abnormal for an 80 year old male, where it would fall near the middle of the "normal" range. Assuming that the latter individual is healthy, the information would be transmitted to him that while his smell ability is clearly diminished from what it was a few years before, it falls within the normal range of males within his age category.

Norms based upon the administration of the Smell Identification TestTM to 961 women and 649 men of various ages are presented in Tables 1 and 2. Despite these rather large sample sizes, it should be noted that these norms are currently being expanded and suffer from the limitation of having only a few subjects in certain age categories. For example, the numbers of children within the 4-5 yr age range is very small, necessitating caution in the interpretation of test scores from this group. The sample

of subjects upon which these norms was developed included most of the persons described in Experiment 2 of Section I of this manual. The remaining additional subjects largely consisted of more persons tested in homes for the elderly and children tested at various summer camps within the Philadelphia area. Although no claim can be made that these norms represent a truly random sample of the population at large, they represent the largest empirical collection of data on human smell function ever collected. Because of the large number of subjects examined, and because of the representation of persons from a wide range of education levels, occupations, ethnic backgrounds, and life styles, it is unlikely that these norms deviate markedly from the population as a whole. Future editions of this manual will include further breakdowns of population subgroups by factors such as occupation, ethnic background, etc., as sample sizes warrant. These norms will be updated from time to time as more "normal" individuals are evaluated.

Interpretation of a Subject's Test Score in Relation to Normative Data

The use of Tables 1 and 2 in determining an individual's percentile score is straightforward. First, the subject's total number of correct responses (maximum possible = 40) is established by use of the test's scoring key. Second, this test score is located in the far left column of Table 1 for women and Table 2 for men. The age group of the subject is then located along the top of the appropriate table and the subject's percentile score is read as the intersection of the test score row and age group column. For example, if a 47 year old female scored 35 on the test, the percentile at which she falls would be the 15th. Thus, 15% of the group of "normal" females achieved a score at or below that value, with the remainder scoring above. Such a score is clearly at the lower end of the normal group, but not markedly abnormal, as would be a score of 10 for such an individual.

In general, the following criteria have been developed for establishing a patient's olfactory diagnosis using this test instrument. With the exception of boys aged 15 yrs or less and girls aged 10 yrs or less, this classification scheme is based upon a characterization of the test scores that is independent of the age of the subjects (e.g., despite the fact that a score of 18 is in the middle of the "normal" range of scores for a 77 year old male, it is still indicative of the absolute condition of anosmia). In this classification scheme, anosmia is defined as total inability to perceive qualitative odor sensations (independent of the "common chemical sense" sensations perceived

via the trigeminal nerve), whereas microsmia is defined operationally as decreased smell ability. The term microsmia was chosen to specifically relate to the scores on the Smell Identification Test^M, and does not draw a distinction between "partial anosmia" and "hyposmia" [21]. Because the operational establishment of either of these latter conditions requires both the testing of a large number of odorants and a considerable amount of effort (both of which are not practical in the clinic), the term microsmia accurately describes the condition of lessened smell function without being operationally or conceptually related to concepts which cannot be objectively confirmed in the typical clinical situation. Even if time permitted extensive threshold testing in such a context, olfactory detection threshold measures are frequently misleading, as a number of totally anosmic individuals with inflamed intranasal membranes evidence normal or supranormal detection thresholds.

SMELL IDENTIFICATION TEST SCORE OLFACTORY DIAGNOSIS

00 - 05	Probable Malingering
06 - 19	Total Anosmia
20 - 33	Microsmia (males only)
20 - 34	Microsmia (females only)
34 - 40	Normosmia (males only)
35 - 40	Normosmia (females only)

It should again be emphasized, as indicated in Tables 1 and 2, that these criteria do not apply in the case of boys aged 15 and below and girls aged 10 and below. For these individuals, the border between normosmia and microsmia has been adjusted downward to reflect the empirical distribution of their percentiles. It should also be emphasized that the choice of these cutoff values was made on empirical grounds. Thus, in the case of the total anosmia and probable malingering categories, results from totally anosmic individuals and persons instructed to malingering revealed these values to be the appropriate cutoffs (see Fig. 4 of this manual). In addition, detailed analyses of the substances that patients reported as being detectable revealed that patients with scores below 20 noted the detection of only household substances known to have strong trigeminal stimulative properties (unpublished data). The border between microsmia and normosmia was chosen to represent a value close to the 10th percentile of adults within the middle age range.

As more individuals are added to this data base, it is conceivable that these criteria may be modified slightly. At the present time, however, they serve as relatively well-defined points and generally allow accurate categorization of smell

Table 1: Percentile Table for Females (N = 961). Numbers in body of table are percentile scores corresponding to Smell Identification Test™ scores in each age category. Numbers at bottom of table refer to sample sizes within each age category. The three solid lines crossing the columns of percentile scores represent, from bottom to top, the regions of the 25th percentile, the 50th percentile (median), and the 75th percentile, respectively. See text for details.

		AGE GROUP																			
		04-05	06-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96+
SMELL IDENTIFICATION TEST SCORE	NORMOSMIA																				
	40	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
	39	99	99	93	75	89	88	84	81	86	81	91	91	96	95	98	99	99	99	99	99
	38	92	93	70	57	59	74	65	59	73	66	85	77	87	85	98	97	99	99	99	99
	37	83	93	49	37	44	50	55	34	73	42	65	57	75	72	94	91	99	99	99	99
	36	75	78	38	22	29	37	33	23	46	24	47	34	64	66	86	84	99	99	99	99
	35	67	68	30	18	19	27	23	19	41	15	41	29	58	50	80	81	97	96	99	80
	34	67	49	23	10	10	6	14	13	23	10	1	26	39	43	73	81	93	96	93	80
	33	58	43	16	10	10	10	10	18	18	18	24	26	25	38	63	81	93	83	93	80
	32	58	34	10	10	10	10	10	18	18	18	17	21	29	63	78	93	78	93	93	80
	31	58	32																		
	30	58	23																		
	29	50	21																		
	MICROSMIA																				
	28	17																			
	27	42	15																		
	26	33	13																		
	25	25	10																		
	24	25																			
	23	10																			
	22																				
	21																				
	20																				
	19																				
	18																				
	17																				
	16																				
	15																				
	14																				
ANOSMIA																					
PROBABLE MALINGERING																					

Table 2: Percentile Table for Males (N = 649). Numbers in body of table are percentile scores corresponding to Smell Identification Test™ scores in each age category. Numbers at bottom of table refer to sample sizes within each age category. The three solid lines crossing the columns of percentile scores represent, from bottom to top, the regions of the 25th percentile, the 50th percentile (median), and the 75th percentile, respectively. See text for details.

		AGE GROUP																			
		04-05	06-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91+	
SMELL IDENTIFICATION TEST SCORE	NORMOSMIA	40	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	
		39	99	99	99	96	88	92	90	91	79	96	94	99	99	99	99	99	99	99	99
SMELL IDENTIFICATION TEST SCORE	MICROSMIA	38	99	99	90	80	71	74	70	71	79	61	99	81	94	99	97	99	99	99	99
		37	99	98	81	58	56	54	52	63	71	39	70	56	81	97	94	94	99	99	99
SMELL IDENTIFICATION TEST SCORE	ANOSMIA	36	99	89	62	39	35	42	41	42	54	28	21	38	75	94	85	88	99	99	99
		35	99	80	54	33	24	28	22	29	29	22	29	37	63	91	82	87	99	99	99
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	34	92	72	47	26	13	16	15	21	21	11	25	11	56	88	82	81	89	92	99
		33	92	63	32	18	10	10	10	18	21	10	25	10	44	76	73	75	99	92	99
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	32	92	57	27	11	11	13	13	13	13	10	25	31	67	73	75	96	92	99	99
		31	85	52	23	10	11	11	11	10	11	10	17	25	67	70	76	86	85	99	99
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	30	85	48	23	18	10	10	10	10	10	10	17	25	67	70	75	82	85	99	99
		29	85	41	18	14	14	14	14	14	14	13	19	19	52	67	75	82	77	90	90
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	28	69	35	13	13	13	13	13	13	13	12	19	19	46	61	69	82	69	90	90
		27	62	30	10	10	10	10	10	10	10	10	19	19	46	52	69	82	62	90	90
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	26	39	24	10	10	10	10	10	10	10	10	16	16	45	49	69	77	61	90	90
		25	39	24	10	10	10	10	10	10	10	10	16	16	36	48	69	73	46	90	90
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	24	39	20	10	10	10	10	10	10	10	10	16	16	36	48	69	73	39	90	90
		23	38	15	10	10	10	10	10	10	10	10	16	16	30	46	63	73	31	80	80
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	22	38	15	10	10	10	10	10	10	10	10	16	16	30	42	56	73	31	80	80
		21	38	11	10	10	10	10	10	10	10	10	13	13	24	42	56	64	31	70	70
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	20	23	10	10	10	10	10	10	10	10	10	13	13	24	33	56	64	31	70	70
		19	15	10	10	10	10	10	10	10	10	10	13	13	18	30	56	55	31	70	70
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	18	10	10	10	10	10	10	10	10	10	10	12	12	18	27	56	46	31	70	70
		17	10	10	10	10	10	10	10	10	10	10	12	12	15	24	56	46	31	70	70
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	16	15	10	10	10	10	10	10	10	10	10	10	10	24	50	45	31	70	70	70
		15	15	10	10	10	10	10	10	10	10	10	10	10	15	21	38	45	31	60	60
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	14	14	10	10	10	10	10	10	10	10	10	10	10	18	28	38	36	19	50	50
		13	14	10	10	10	10	10	10	10	10	10	10	10	18	37	36	15	15	50	50
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	12	12	10	10	10	10	10	10	10	10	10	10	10	18	31	32	10	10	40	40
		11	11	10	10	10	10	10	10	10	10	10	10	10	15	19	23	14	10	40	40
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	10	9	10	10	10	10	10	10	10	10	10	10	10	10	10	14	10	10	20	20
		9	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	8	7	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
		7	6	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	6	5	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
		5	4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	4	3	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
		3	2	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	2	1	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
		1	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
SMELL IDENTIFICATION TEST SCORE	PROBABLE MALINGERING	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

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